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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/629,286	07/29/2003	Patrick D. McCusker	03CR166/KE	5711

7590 04/20/2006

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ART UNIT	**PAPER NUMBER**
3661	

DATE MAILED: 04/20/2006

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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 10/629,286
Filing Date: July 29, 2003
Appellant(s): MCCUSKER ET AL.

MAILED

APR 2 0 2006

GROUP 3600

Nathan O. Jensen
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed February 9, 2006, appealing from the Office action mailed July 15, 2005.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

Federal Aviation Administration, "AC 25-23- Airworthiness Criteria for the Installation Approval of a Terrain Awareness and Warning System(TAWS) for Part 25 Airplanes", (May 22, 2000)

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1 through 3, 9 through 15, 17, 18, and 19 are rejected under 35 U.S.C. 102(e) as being anticipated by Ybarra et al., 2004/0068372.

As per claims 1 through 3, 9 through 15, 17, 18, and 19, Ybarra et al. disclose predicting an intended path of the aircraft, identifying a potential hazard to the aircraft along the intended path in paragraph 18; determining a distance from the potential hazard that the aircraft is required to maintain in table 34; determining an ability of the aircraft to maneuver to avoid the identified hazard and to remain further from the identified hazard than the distance in paragraph 18; determining a probability that the aircraft will not maintain the distance from the identified hazards and alerting a pilot of the aircraft if the probability is greater than a predetermined level in paragraph 33; receiving inputs representative of a weather event proximal the aircraft and receiving inputs representative of an aircraft proximal the aircraft in paragraph 18; identifying a potential hazard further includes accessing information representative of elevations of terrain proximal the aircraft in paragraph 18; determining the ability of the aircraft to maneuver further comprises analyzing inputs from a plurality of aircraft sensors to ascertain a current configuration of the aircraft in paragraph 9, 18, and 41; the aircraft sensors measure at least one of an aircraft flap position, an aircraft slat position, a landing gear position, a throttle position, and an engine-out status for any engine of the aircraft in paragraph 41; in paragraph 9; determining the ability of the aircraft to maneuver further comprises determining the current operating state of the aircraft in

paragraph 9; predicting an intended path of the aircraft includes obtaining input from an onboard avionics navigation system in paragraph 21; alerting the pilot includes highlighting at least one of a graphical representation of the potential hazard, and at least part of a graphical representation of the intended path of the aircraft in paragraph 25 and 17, the conventional systems will highlight hazards according to the government specifications mentioned; and accessing information relative to areas of restricted airspace proximal the aircraft; accessing separation information that provides a distance by which the aircraft must be separated from the restricted airspace; determining a possibility that the aircraft, traveling along the intended path, will be less than the distance from the restricted airspace, and advising a pilot of the aircraft if the possibility is above a predetermined threshold in paragraph 18. Restricted airspace is a traffic condition.

As per claim 19, the invention of Ybarra et al. is capable of providing a plurality of warnings of two weather events, aircraft traffic and terrain. This is functional language.

Claims 4, 5, 6, and 7 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ybarra et al., 2004/0068372, in view of Myers, 6085147.

Ybarra et al. disclose the limitations as set forth above. Ybarra et al. do not disclose the performance characteristics include aircraft ceiling and aircraft range. Myers teaches using the performance characteristics of aircraft ceiling and aircraft range on lines 38-40, on column 5. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use the range and ceiling of Myers

because such modification would optimize the cost of operation of the vehicle(lines 8-10, on column 1 of Myers) when determining whether or not to provide a warning.

Claim 16 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ybarra et al., 2004/0068372, in view of Campbell, 2004/0024500.

Ybarra et al. disclose the limitations as set forth above. Ybarra et al. do not disclose determining the current operating state includes determining at least one of an engine temperature, and an RPM of an engine of the aircraft. Campbell teaches determining the current operating state includes determining at least one of an engine temperature, and an RPM of an engine of the aircraft in paragraph 27. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use the measurements of Campbell in the invention of Ybarra et al. because Ybarra et al. discloses using available thrust as a performance measure in paragraph 46, and in paragraph 41, discloses changing base values based on sensor readings. Campbell teaches that the sensor reading used to determine available thrust include engine temperature and RPM. Using these specific measurements is a design choice.

Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Ybarra et al., 2004/0068372, in view of Myers, 6085147, as applied to claims 4 and 7 above, and further in view of Campbell, 2004/0024500.

Ybarra et al. and Myers disclose the limitations as set forth above. Ybarra et al. and Myers do not disclose determining the current operating state includes determining at least two of an engine pressure ratio for any engine of the aircraft, engine temperature, and an RPM of an engine of the aircraft. Campbell teaches determining

the current operating state includes determining at least two of an engine pressure ratio for any engine of the aircraft, engine temperature, and an RPM of an engine of the aircraft in paragraph 27. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use the measurements of Campbell in the invention of Ybarra et al. and Myers because Ybarra et al. and Myers disclose using available thrust as a performance measure in paragraph 46, and in paragraph 41, discloses changing base values based on sensor readings. Campbell teaches that the sensor reading used to determine available thrust include engine temperature and RPM. Using these specific measurements is a design choice.

(10) Response to Argument

The Appellant's arguments with respect to claims 1 and 11 are the same and will be treated together. Appellant argues that Ybarra fails to disclose "alerting a pilot of the aircraft if the probability that the aircraft will not maintain the distance from the identified hazards *is greater than a predetermined level.*" Appellant has not addressed the remarks in both the final office action of July 15, 2005, and the advisory action of November 17, 2005, that set forth the position that risk is another term for probability. According to the *Merriam Webster Collegiate Dictionary*, tenth edition, 1997, page 1011, risk is defined as "the chance of loss or the perils to the subject matter of an insurance contract; also : the degree of **probability** of such a loss". Ybarra, in paragraph 33, clearly discloses alerting the pilot based on risk (probability) assessments. This assessment must compare the current level of risk to an acceptable level of risk. This acceptable level would correspond to Appellant's "predetermined level". In paragraph

34, Ybarra, discloses that the working value of the aircraft is adjusted based on actual real-word conditions by taking into account adjustment values. For example, an adjustment may be made if the flight crew is inexperienced. This adjustment would cause the risk of collision to increase compared to the same situation with a more experienced flight crew. If the risk (probability) increased enough to reach a threshold, or unacceptable level, then an alert or advisory would be issued to the pilot. Appellant seems to rely on the fact that Ybarra does not explicitly use the term "probability". But Ybarra clearly reads on the claims when risk is interpreted properly as the equivalent of probability.

The second argument deals with whether or not the cited reference discloses "accessing information relative to areas of restricted airspace proximal to the aircraft", as in Appellant's claim 17. The cited section of Ybarra (paragraph 24) discloses "the airport data generally includes terrain data associated with an airport and descriptions of approaches and runways into the airports the host aircraft is expected to access to during the mission." The aircraft would only be given clearance to one approach at a time and the other approaches would be restricted. Furthermore, in paragraph 33 Ybarra discloses that the location of adverse weather is given so that it may be avoided. The space occupied by the weather can be viewed as restricted airspace. The space occupied by other aircraft can also be viewed as restricted airspace. Finally, in Table 4, on page 7 of Ybarra it is disclosed that a "minimum terrain clearance distance" is given. This represents a section of airspace above the terrain that is restricted and not to be

restricted and not to be occupied by the aircraft. Ybarra is going to reference this value to determine and issue collision alerts.

The argument with respect to claim 18 addresses the claim limitation of "a visual notification apparatus configured to highlight at least one of a graphical representation of a potential hazard and at least part of a graphical representation of the flight path of the aircraft." Paragraph 25 of Ybarra discloses providing advice to the display. What was pointed out in the response to arguments in the final office action of July 15, 2005, is that standards disclosed in paragraph 17 read on the claimed limitations. In paragraph 17, Ybarra discloses "the visual advice may be presented by symbols or colors or a graphic presentation for display to a flight crew member. Such a system may include any conventional system modified as described therein. Conventional systems include, for example, systems as specified in DO-185A, as to traffic collision avoidance, and as specified in Advisory Circular AC 25-18, **AC 25-23**, or TSO-C151a..." These are all standards, mostly by the FAA, that should be known to one of ordinary skill in the art. AC 25-23 describes on pages 16-17, how a terrain display should display terrain alerts and preferably use color to highlight the threat. This limitation is so well known in the art that it would almost be considered standard equipment on any newly built large aircraft.

The remaining arguments by Appellant rely on the arguments addressed above and are not convincing for the same reasons.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Brian J. Broadhead

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Thomas G. Black

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THOMAS G. BLACK
SUPERVISORY PATENT EXAMINER
GROUP 3600

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

AC 25-23
DATE: 5/22/00

Airworthiness Criteria for the Installation Approval of a Terrain Awareness and Warning System (TAWS) for Part 25 Airplanes

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1. PURPOSE.

a. This Advisory Circular (AC) describes an acceptable means for obtaining FAA airworthiness approval for the installation of a Terrain Awareness and Warning System (TAWS) that has been approved under Technical Standard Order (TSO)-C151a, Terrain Awareness and Warning System, or later revisions. The FAA's TSO process is a means for obtaining FAA design and performance approval for an appliance, system, or product; however, the TSO does not provide installation approval. This AC serves to provide guidance for designing an acceptable installation for a TAWS that is compliant with TSO-C151a. The guidance provided is specific to installations of these systems on transport category airplanes certificated under 14 CFR part 25 [commonly referred to as part 25 of the Federal Aviation Regulations (FAR)]. It describes the airworthiness considerations for such installations as they apply to the unique features of the TAWS and the interface of the TAWS with other systems on the airplane.

b. The guidance provided in this document is directed to airplane and avionics manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration transport airplane type certification engineers and their designees.

c. Like all advisory circular material, this AC is not, in itself, mandatory, and does not constitute a regulation. It is issued to describe an acceptable means, but not the only means, for demonstrating compliance with the requirements for transport category airplanes. Terms such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this document is used. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration and industry experience in determining compliance with the pertinent regulations.

d. This advisory circular does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

2. RELATED REGULATIONS AND DOCUMENTS.

a. **Regulations.** 14 CFR parts:

§ 25.1301	Function and installation
§ 25.1303	Flight and navigation instruments
§ 25.1309	Equipment, systems, and installations
§ 25.1321	Arrangement and visibility
§ 25.1322	Warning, caution, and advisory lights
§ 25.1333	Instrument systems

§ 25.1351	Electrical systems and equipment -- General
§ 25.1353	Electrical equipment and installations
§ 25.1357	Circuit protective devices
§ 25.1381	Instrument lights
§ 25.1383	Landing lights
§ 25.1431	Electronic equipment
§ 25.1459	Flight recorders
§ 25.1529	Instructions for Continued Airworthiness
§ 25.1541	Markings and placards -- General
§ 25.1581	Airplane flight manual -- General
§ 25.1585	Operating procedures
§ 91.223	Terrain awareness and warning system
§ 121.354	Terrain awareness and warning system
§ 121.360	Ground proximity warning-glide slope deviation alerting system
§ 135.153	Ground proximity warning system
§ 135.154	Terrain awareness and warning system

b. **FAA Advisory Circulars (AC), Orders, and Technical Standard Orders (TSO).** The AC's and TSO's listed below can be obtained from the U.S. Department of Transportation, General Services Section, M-443.2, Washington, D.C. 20590.

- AC 20-112, Airworthiness and Operational Approval of Airborne Systems to be Used in Lieu of Ground Proximity Warning System, February 19, 1981.
- AC 20-115B, Radio Technical Commission for Aeronautics, Inc. Document RTCA/DO-178B, January 11, 1993
- AC 20-130A, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, June 14, 1995.
- AC 20-136, Protection of Aircraft Electrical/Electronic System Against the Indirect Effects of Lightning, March 5, 1990

- AC 20-138, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System, June 25, 1994.
- AC 21-16D, Radio Technical Commission for Aeronautics Document DO-160D
- AC 25-4, Inertial Navigation Systems (INS), February 18, 1966.
- AC 25-10, Guidance for Installation of Miscellaneous Nonrequired Electrical Equipment, March 6, 1987.
- AC 25-11, Transport Category Airplane Electronic Display Systems, July 16, 1987.
- AC 25-12, Airworthiness Criteria for Approval of Airborne Windshear Warning Systems in Transport Category Airplanes, November 2, 1987.
- AC 25-16, Electrical Fault and Fire Prevention and Protection, April 5, 1991.
- AC 25.1309-1A, Systems Design and Analysis, June 21, 1988.
- AC 25.1581-1, Airplane Flight Manual, July 14, 1997.
- AC 90-45A, Approval of Area Navigation Systems for Use in the U.S. National Airspace System, February 21, 1975.
- FAA Order 8110.4A, Type Certification Process
- FAA Order 8260.3B, United States Standard for Terminal Instrument Procedures (TERPS)
- TSO-C10b, Altimeter, Pressure Actuated, Sensitive Type
- TSO-C67, Airborne Radar Altimeter Equipment
- TSO-C92c, Airborne Ground Proximity Warning Equipment
- TSO-C106, Air Data Computer
- TSO-C113, Airborne Multipurpose Electronic Displays
- TSO-C115, Airborne Navigation Equipment Using Multi-Sensor Inputs
- TSO-C117a, Airborne Windshear Warning and Escape Guidance Systems for Transport Airplanes

- TSO-C129a, Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
- TSO C145, Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
- TSO-C151a, Terrain Awareness and Warning System

c. **Industry documents.**

(1) The Radio Technical Commission for Aeronautics (RTCA) documents listed below are available from RTCA, Inc., 1140 Connecticut Avenue N.W., Suite 1020, Washington, D.C. 20036-4001.

- DO-160D, Environmental Conditions and Test Procedures for Airborne Equipment
- DO-161A, Minimum Performance Standards - Airborne Ground Proximity Warning Equipment
- DO-178B, Software Consideration in Airborne Systems and Equipment Certification
- DO-200, Preparation, Verification and Distribution of User-Selectable Navigation Databases
- DO-200A, Standards for Processing Aeronautical Data
- DO-208, Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System

(2) The Society of Automotive Engineers (SAE) documents listed below are available from SAE, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001.

- Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
- Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly Integrated or Complex Aircraft Systems

3. DEFINITIONS.

a. **Alert:** A visual, aural, or tactile stimulus presented either to attract attention or to convey information regarding system status or condition, or both

b. **Aural Alert:** A discrete sound, tone, or verbal statement used to enunciate a condition, situation, or event.

c. **Caution Alert:** An alert requiring immediate flightcrew awareness. Subsequent corrective action normally will be necessary.

d. **Class A TAWS Equipment:** A class of equipment that is defined in TSO C151a.

(1) As a minimum, it will provide alerts for the following circumstances:

- Reduced required terrain clearance.
- Imminent terrain impact
- Premature descent.
- Excessive rates of descent.
- Excessive closure rate to terrain.
- Negative climb rate or altitude loss after take-off.
- Flight into terrain when not in landing configuration.
- Excessive downward deviation from an ILS glideslope.
- Descent of the airplane to 500 feet above the terrain or nearest runway elevation (voice callout "Five Hundred") during a non-precision approach.

(2) This class of TAWS equipment also must provide a terrain awareness display of the surrounding terrain and/or obstacles relative to the airplane. See TSO C151a, Table 11-1, to determine which operating rules and aircraft configurations require Class A TAWS equipment.

e. **Class B TAWS Equipment:** A class of equipment that is defined in TSO C151a.

(1) As a minimum, it will provide alerts for the following circumstances:

- Reduced required terrain clearance.
- Imminent terrain impact.
- Premature descent.
- Excessive rates of descent.
- Negative climb rate or altitude loss after take-off.
- Descent of the airplane to 500 feet above the terrain or nearest runway elevation (voice callout "Five Hundred") during a non-precision approach.

(2) This class of TAWS equipment does not require a terrain awareness display of the surrounding terrain and/or obstacles relative to the airplane. See TSO C151a,

Table 11-1, to determine which operating rules and aircraft configurations require Class B TAWS equipment.

f. **Controlled Flight Into Terrain (CFIT):** An accident or incident in which the airplane, under the flightcrew's control, is inadvertently flown into terrain, obstacles, or water without either sufficient or timely flightcrew awareness to prevent the event, or both.

g. **Failure:** The inability of the equipment or any sub-part of that equipment to perform within previously specified limits

h. **False Alert:** A warning or caution that occurs when the design terrain warning or caution threshold of the system is not exceeded.

i. **Forward Looking Terrain Avoidance (FLTA):** A TAWS functional requirement to provide look-ahead terrain and obstacle protection along and below the airplane's lateral and vertical flight path.

j. **Hazard:** A state or set of conditions that, together with other conditions in the environment, could lead to an accident.

k. **Hazardously Misleading Information (HMI):** An incorrect depiction of the terrain threat relative to the airplane during an alert condition (excluding source data).

l. **Imminent Terrain Impact:** An alert that will notify the flightcrew when the flight path of the airplane is projected to impact terrain.

m. **Nuisance Alert:** An alert that is caused by improper setting of the terrain alerting threshold.

n. **Obstacle:** A human made structure that is in the flight path of the aircraft.

o. **Premature Descent Alert (PDA):** A warning system's ability to detect when the aircraft is hazardously below the normal (approximately 3 degrees) approach path for the nearest runway, and to provide a timely alert.

p. **Required Terrain Clearance (RTC):** The minimum requirements for obstacle terrain clearance as defined by United States Standard for Terminal Instrument Procedures (TERPS) FAA Order 8260.3B and the Aeronautical Information Manual (AIM).

q. **Terrain Awareness and Warning System (TAWS):** A generic term used to describe an alerting system that provides the flightcrew with sufficient information and time to detect a potentially hazardous terrain situation and avoid CFIT.

r. **Terrain Awareness Display:** A display of the surrounding terrain or obstacle(s) relative to the airplane.

s. **Terrain Database:** Terrain or obstacle information stored within a TAWS.

t. **Time-shared Display**: A display that shows terrain information, plus additional information from other systems [e.g., an Electric Flight Instrument System/Navigation Display/Multi-Function Display (EFIS/ND/MFD)].

u. **Visual Alert:** The use of projected or displayed information to present a condition, situation, or event to the flightcrew.

v. **Warning Alert:** An alert for a detected terrain threat that requires immediate flightcrew action.

4. BACKGROUND.

a. **General**. Controlled flight into terrain (CFIT) has been a principal contributor to commercial jet airplane hull losses and fatalities. Before 1975, the worldwide commercial jet airplane fleet averaged approximately eight CFIT accidents per year. When the original Ground Proximity Warning System (GPWS) was first introduced on aircraft in the mid-1970's, it dramatically reduced accident rates. The GPWS is a computer-based system that, among other things, provides the flightcrew with adequate warning (both aural and visual) of inadvertent contact of the airplane with the terrain or other obstacles, taking into account such items as crew recognition and reaction times.

b. **Regulatory Background**. In 1974, the FAA issued Amendments 121-114 and 135-12 (39 FR 44440, December 24, 1974). Those amendments required that all part 121 certificate holders (i.e., those operating large turbine-powered airplanes) and certain part 135 certificate holders (i.e., those operating large turbojet-powered airplanes) install GPWS equipment approved under TSO-C92c (Airborne Ground Proximity Warning Equipment) in their airplanes. (In 1978, the FAA extended this same requirement to part 135 certificate holders operating smaller turbojet-powered airplanes.) That TSO prescribes the minimum performance standards that GPWS equipment must meet to be in compliance with the applicable regulation.

c. **New Systems.** The use of GPWS has not entirely eliminated the problem of CFIT, however, and CFIT accidents continue to occur. Recent advances in terrain mapping technology have led to the development of a new type of GPWS that provides greater situational awareness to flightcrews. It is designed to help reduce the CFIT accident rate even further by providing additional information and warning to the flightcrew in situations where the airplane may be inadvertently approaching significant rising terrain or a man-made obstruction. There is an increased interest in certifying these systems on transport airplanes due to recent and continuing accidents attributed to CFIT.

d. **TSO-C151a.** The FAA has issued Technical Standard Order (TSO)-C151a, Terrain Awareness and Warning System, which prescribes the minimum design standards that a Terrain Awareness and Warning System (TAWS) must meet to be identified with the TSO-C151a marking. The TAWS described in the TSO is representative of the "next generation" GPWS. In addition to the standards and test procedures required for the Forward Looking Terrain Avoidance (FLTA) functions, the TAWS incorporates the standards and test procedures for Basic GPWS equipment (as defined in TSO-C92c and in RTCA document DO-161A, Minimum Performance Standards - Airborne Ground Proximity Warning Equipment). For further in-depth information concerning the TAWS' capabilities, refer to TSO-C151a.

e. **Need for Guidance.**

(1) The FAA's TSO process is a means of obtaining FAA design and performance approval for an appliance, system, or product. However, the TSO does not provide procedures for installation approval or procedures for design or implementation of an installation. With heightened interest by manufacturers and operators to equip transport category airplanes with TAWS systems that are compliant with TSO-C151a, the FAA has recognized the need to establish guidance material for the design and test requirements for the installation of such systems. This Advisory Circular (AC) has been developed as the means for providing such guidance.

(2) This AC describes the airworthiness considerations for designing a TAWS installation. The airworthiness considerations discussed apply only to the interface of the TAWS with other aircraft systems on transport category airplanes.

5. DISCUSSION. The following sections of 14 CFR parts 91, 121, and 135 require the installation of the TAWS:

a. **§ 91.223** states that no person may operate a turbine-powered U.S.-registered airplane configured with 6 or more passenger seats, excluding any pilot seat, unless that airplane is equipped with an approved terrain awareness and warning system that meets the requirements of Class B equipment of TSO-C151a.

b. **§ 121.354** states that no person may operate a turbine-powered airplane unless that airplane is equipped with an approved terrain awareness and warning system, including a terrain awareness display, that meets the requirements for Class A equipment of TSO-C151a.

c. **§ 135.154** states that no person may operate a turbine-powered U.S.-registered airplane configured with 6 to 9 passenger seats, excluding any pilot seat, unless that airplane is equipped with an approved terrain awareness and warning system that meets the requirements of Class B equipment of TSO-C151a. It also states that no person may

operate a turbine-powered U.S.-registered airplane configured with 10 or more passenger seats, excluding any pilot seat, unless that airplane is equipped with a terrain awareness and warning system that meets the provisions of Class A equipment of TSO-C151a.

d. The parts 121 and 135 regulations also mandate that GPWS be replaced with a TAWS approved under TSO-C151a.

6. <u>SYSTEM DESCRIPTION</u>. TAWS is intended to provide flightcrews with aural and visual alert aids aimed at preventing a CFIT accident through increased terrain awareness.

a. **Class A TAWS equipment as defined in TSO-C151a.**

(1) Class A TAWS equipment provides three principal alerting functions. These are:

(a) Forward-Looking Terrain-Avoidance (FLTA) function, which includes:

- Reduced required terrain clearance.
- Imminent terrain impact.

(b) Premature Descent Alert (PDA) function.

(c) Basic Ground Proximity Warning System (GPWS) functions, as defined in TSO-C151a and RTCA Document DO-161A, which include:

- Excessive rates of descent.
- Excessive closure rate to terrain.
- Negative climb rate or altitude loss after take-off.
- Flight into terrain when not in landing configuration.
- Excessive downward deviation from and ILS glideslope.
- Descent of the airplane to 500 feet above the terrain or nearest runway elevation (voice callout "Five Hundred").

(2) The Class A TAWS system will require a display. The terrain display and terrain-threat alerting are made possible by the TAWS' acceptance of a variety of input parameters. These parameters are used in conjunction with a terrain and airport database(s) that reside within the TAWS computer. The Class A TAWS places an airplane symbol on a digital terrain map and applies terrain display algorithms. Terrain mapping information may be provided on either a weather radar (WXR) display, Electronic Flight Instrument System (EFIS) display, or other compatible display screens. Aircraft position information is provided by either the Flight Management Computer (FMC), Global Positioning System (GPS), or other source of positional information that meets the provisions specified in paragraph 11. (Position Source) of this AC.

b. **Class B TAWS equipment, as defined in TSO-C151a.**

(1) Class B TAWS equipment provides three principal alerting functions. These are:

(a) FLTA function, which includes:

- Reduced required terrain clearance
- Imminent terrain impact

(b) Premature Descent Alert (PDA) function

(c) Basic GPWS functions, as defined in TSO-C151a and RTCA Document DO-161A, which include:

- Excessive rates of descent
- Negative climb rate or altitude loss after take-off
- Descent of the airplane to 500 feet above the terrain or nearest runway elevation (voice callout "Five Hundred").

(2) The Class B TAWS will not require a display. If a display is installed with a Class B TAWS, it should meet the provisions of paragraph 13. (Display Presentation) of this AC.

(3) The Class B TAWS equipment will be required to interface with an approved GPS for horizontal position information.

(4) The Class B TAWS will not require an interface to a radio altimeter.

7. AIRWORTHINESS CONSIDERATIONS FOR CERTIFICATION PROGRAMS

a. The scope of the applicant's program should be directed toward airworthiness approval through the Type Certification (TC) or Supplemental Type Certification (STC) process. The guidance provided in this AC also is appropriate for applicants who choose to exercise their Designated Alteration Station (DAS) authorization for STC approval. As part of the amended TC or STC program, the applicant must identify if the changes to the type certificated airplane constitute a significant change, but not one so extensive as to require a new TC in accordance with § 21.19 (Changes Requiring a New Type Certificate). If the design change is considered significant, the certification program must be coordinated with the responsible FAA Directorate, as described in FAA Order 8110-4A, Type Certification.

b. The remainder of this AC describes in detail specific airworthiness considerations that applicants should take into account as part of the certification process.

8. PROJECT SPECIFIC CERTIFICATION PLAN (PSCP). On January 25, 1999, the FAA, in coordination with the Aerospace Industries Association (AIA) and the General Aviation Manufacturers Association (GAMA), introduced The FAA and Industry Guide to Product Certification. This aid communicates the design and production certification process for aircraft. It describes how to plan, manage, and document an effective and efficient product certification process. A crucial part of this process is the development of a "Project Specific Certification Plan (PSCP)." The applicant should develop a comprehensive PSCP that includes the following:

a. **Project Description:** A summary of the project.

b. **System Description:**

(1) A comprehensive system description that includes a brief summary of the product as it relates to existing flight deck displays, sensors, added sensors, switches, annunciator lights, control panels, electrical components, interior arrangement, other interfaces, product part number, etc.

(2) A layout and description of any changes to the flight instrument panels and flight engineer panels.

(3) Information regarding software aspects of certification and any application-specific integrated circuits (ASIC) approved under TSO-C151a should be referenced, and made available upon request. Additional documentation may be required for added features that were not approved under TSO-C151a.

c. **Project Schedule:**

(1) A detailed project schedule that identifies all major milestones and schedules for any required deliverables (i.e., test plans).

(2) Schedules for operational and maintenance aspects, as well as foreign authority validation requirements.

d. **Certification Basis and Means of Compliance:**

(1) A certification matrix that identifies the applicable regulations, AC's, current policies, certification basis, and the procedures or methods that will be used to comply with those regulations.

(2) Any testing or analyses applicable to the project that have been previously approved by the FAA under an STC, TC, TSO, or Parts Manufacturer Approval (PMA) held by the applicant. The approval date, letter reference number, and references as to how the specific approval was granted (i.e., STC, TSO, letter of approval, etc.) should be included in this section.

e. **Communication and Coordination:**

(1) If applicable, identification of all designated engineering representatives (DER), designated airworthiness representatives (DAR), designated manufacturing inspection representatives (DMIR), or designated alteration station (DAS) specialists working on the program.

(2) Identification of all delegated functions, which should include any stipulations, coordination, and limitations that are placed upon those delegations.

f. **Human Factors Plan:** This section should address human factors issues and provide human factors support for decisions regarding the flightcrew interface issues resulting from the TAWS installation.

g. **Testing Plan:** This section should contain the requirements for the planning, preparation, and conduct of FAA required testing, including any delegations.

h. **Conformity Plan:** This section should describe the activities associated with conformity of parts, simulators, and aircraft installations.

i. **Continued Airworthiness Plan:** This section should provide the instructions for continued airworthiness for the TAWS installation.

j. **Compliance Documentation:** This section should describe the procedures for submittal and processing of compliance documentation.

9. <u>SYSTEM SAFETY ASSESSMENT.</u>

a. The applicant should perform a system safety assessment (SSA) to establish the hazards associated with the proposed installation. The applicant should develop the SSA in accordance with the guidance provided in AC 25.1309-1A (*System Design and Analysis*) and Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4761 (Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment).

b. The TSO-C151a requires a probability of 10^{-5} for unannunciated failure, hazardously misleading information (HMI), and false alerts at the box level. Therefore, the box as installed must meet the following criteria:

(1) The probability of a failure that would lead to the loss of all functions as they are described in paragraph 6. (System Description) of this AC shall be less than or equal to 10^{-3} per flight hour.

(2) The probability of a false caution and/or warning alert due to undetected or latent failures shall be less than or equal to 10^{-4} per flight hour.

(3) The probability of an unannunciated failure of the system to provide the required alerting functions due to undetected or latent failures shall be less than or equal to 10^{-4} per flight hour.

(4) The probability of the system to provide HMI to the TAWS display due to undetected or latent failures shall be less than or equal to 10^{-4} per flight hour.

(5) Failure of the installed TAWS shall not degrade the integrity of any essential or critical system installed in the airplane with which the TAWS interfaces.

10. SOFTWARE. The applicant should provide evidence that the TAWS software meets the requirements of TSO-C151a and that it meets the appropriate software levels for any added feature (s).

11. POSITION SOURCE. TAWS uses the estimated position of the airplane with reference to the terrain/obstacle to determine when an alert should be annunciated. The applicant should provide evidence that the TAWS position source (horizontal and vertical) is suitable for each phase of flight (i.e., enroute, remote/oceanic, terminal, and approach, as provided by TSO-C151a, Appendix 1, Section 10) for which approval is sought.

a. **Horizontal Position Source.**

(1) TAWS that interface with previously approved navigation systems:

(a) Class A equipment may use approved Area Navigation (RNAV), which may include GPS.

(b) Class B equipment is required to interface with an approved GPS for horizontal position.

(c) Previously approved RNAV and GPS systems that are used for navigation are considered suitable for TAWS horizontal position inputs.

(d) The RNAV system must meet the requirements of TSO-115, or be installed in accordance with AC 90-45A for RNAV systems.

(e) GPS must meet the requirements of TSO-C129a, or be installed in accordance with AC 20-130A and/or AC 20-138.

(f) If a Wide Area Augmentation System (WAAS) is used as a position source, it should meet TSO C-145.

(g) TAWS functions that require this navigation source for operations should be automatically disabled when the source has degraded to a point where its accuracy can no longer support the TAWS functions (i.e., IRU, dead reckoning). An annunciation of this loss of function is required. If the installation does not provide this automatic feature, then an indication should be provided to the flightcrew that the function is no longer available, and the appropriate crew action should be noted in the AFM. A means for testing the position source for accuracy and reliability is unnecessary for these systems.

(2) TAWS equipment with internal GPS position source: Class A and Class B equipment that use a GPS internal to the TAWS for horizontal position information, must use a GPS that is capable of detecting a positional error that exceeds the appropriate alarm limit for the existing phase of flight, in accordance with DO-208 or equivalent. When this alarm limit is activated, the GPS-computed position is considered unsuitable for the TAWS and the functions that require GPS for operations should be automatically disabled and an annunciation provided to the flightcrew. If the installation does not provide this automatic feature, then an indication should be provided to the flightcrew that the function is no longer available, and the appropriate crew action should be noted in the AFM. This type of TAWS equipment will not be approved for navigation unless it meets the provisions of paragraph 11.a.(1) of this AC. The applicant must be able to demonstrate that the TAWS, as installed on the aircraft, provides the appropriate position information (latitude/longitude) for the TAWS functions.

b. **Vertical Position Source.** The following sources are considered suitable for use in establishing vertical position. They may be used as a sole source or in combination. The applicant must be able to demonstrate that the TAWS, as installed on the aircraft, provides the appropriate vertical information for the TAWS functions.

(1) Barometric Altitude. Vertical position information provided by a barometric altitude source that meets the requirements of TSO-C10b, or later versions, is considered acceptable as a source of vertical position information.

(2) Radio Altimeter. Vertical position information provided by a radio altimeter that meets the accuracy specified in TSO-C67 or later versions, is considered acceptable as a source of vertical position information. Class B equipment does not require a radio altitude input.

(3) Air Data Computers. Vertical position information provided by an air data computer that meets the accuracy requirements of TSO-C106, or later versions, is considered acceptable as a source of vertical position information.

(4) GPS. Vertical position information provided by GPS may be used in combination with other sources of vertical position. If GPS is used as the only means for the determination of vertical position then it must meet the requirements of TSO-C145, or later versions.

12. TERRAIN DATABASE. The terrain database for TAWS has been validated via the TSO-C151A authorization process, so there is no need to revalidate the database during the installation process. However, there are two areas of concern that must be addressed during the installation process:

a. **Updates**. The installed system must be capable of accepting updated terrain databases (and obstacle databases as well, if included). The TAWS manufacturers must have a procedure in place whereby the manufacturer can inform the airplane owner/operator about updates, or the airplane owner/operator can learn about updates. The procedure must contain sufficient information to enable the owner/operator to make a logical safety decision as to whether it is appropriate to purchase and install the update. This information should be contained in the instructions for continued airworthiness.

b. **Valid Regional Data.** The Instructions for Continued Airworthiness should identify the procedures for determining the status of the terrain database. Operators should use this information to determine if the current terrain database is appropriate for the area of intended operation

13. DISPLAY PRESENTATION. The terrain display for TAWS is primarily a strategic planning tool that the flightcrew will use to identify potential flight vertical of horizontal errors and correct these errors before an alert occurs. It is not intended for tactical navigation during alert conditions. When an alert occurs, the flightcrew should perform the appropriate procedures before referencing the terrain display for information.

NOTE: A terrain display is not mandatory for Class B equipment. (For further definition, see paragraph 6.b. of this AC and TSO-C151a.)

a. **Terrain Display**.

(1) The TAWS equipment approved under TSO-C151a must be capable of providing terrain and alerting data to display hardware. The display hardware may be stand alone or interfaced with existing equipment, such as a weather radar (WXR), navigation displays, or other compatible display systems. The actual display presentation format that the flightcrew sees will depend on the onboard display hardware, the options made available by the TSO-C151a manufacturer, and the features desired by the customer/user. Regardless of what format is used, the display presentation must enhance the flightcrew's terrain situational awareness.

(2) The terrain display system is an output from the TAWS; therefore:

(a) the possibility of failure of that system should be no greater than 10^{-3} per average flight hour, and

(b) the possibility of misleading information on the display due to undetected or latent failures, should be no greater than 10^{-4} per average flight hour.

(3) During the development of the TAWS equipment, the applicant should use a representative sample of pilots to participate in the design and evaluation process for the proposed presentation format.

(4) The applicant should consider the selection of a terrain display where the display is used for multiple functions. In these cases, a means should be provided to select and de-select the display of terrain. However, care must be exercised in the selection of such a multifunction implementation, to ensure that the display sharing is appropriate for the specific functions. The use of the TAWS situation awareness display should not unacceptably detract from the usability of existing functions. Since the TAWS display is not to be used for navigation, the use of the display should not impair the ability of the pilot to perform required navigation functions. An example of such an impairment would be an installation that forces the pilot to chose between the TAWS display and the needed navigation information in situations where both are likely to be used simultaneously and continuously (e.g., instrument approach in the vicinity of hazardous terrain). If the timesharing of the display between TAWS and other functions is deemed acceptable, the design must facilitate simple switching between the functions, with minimal time delays, so that both functions are sufficiently accessible in realistic flight scenarios.

(5) The terrain display should be installed in a location that is acceptable for monitoring by the pilot as a planning tool to identify potential flight path conflicts. In general, the terrain display should be in a location similar to other situation awareness displays, such as electronic maps and weather radar.

b. **Terrain Display Presentation**. TAWS equipment shall be designed to interface with a terrain display, either color or monochromatic. If there are multiple terrain views available, at least one terrain display shall be capable of providing all of the following terrain-related information:

~~(1) The terrain should be depicted relative to the airplane's position such that the pilot may estimate the relative bearing to the terrain of interest.~~

(2) The terrain should be depicted relative to the airplane's position such that the pilot may estimate the distance to the terrain of interest.

(3) The terrain depicted should be oriented to either the heading or track of the airplane. In addition, a north-up orientation may be added as a selectable format.

(4) Variations in terrain elevation depicted relative to the airplane's elevation (above and below) should be visually distinct. Terrain that is more than 2000 feet below the airplane's elevation need not be depicted.

(5) Terrain that generates alerts should be displayed in a manner to distinguish it from non-hazardous terrain, consistent with the caution and warning alert level.

(6) The terrain display presentation should be clear, unambiguous, and readily usable by the flightcrew during day and night operations under all ambient lighting conditions expected in service.

(7) The terrain display should be viewable in direct sunlight, and at least one display must be viewable by one of the pilots.

(8) An inhibited failed and/or inoperative TAWS should be indicated to the flightcrew in a manner consistent with the flight deck design philosophy.

(9) The terrain display presentation should complement and be compatible with the terrain alerting function of the TAWS.

(10) Terrain mapping should allow the flightcrew to determine relative terrain elevation.

(11) The terrain display should be designed so that the flightcrew can readily determine if terrain is a threat to the airplane.

(12) The colors and/or textures used for threat terrain should be intuitive and indicate the immediacy of the threat.

(13) If the terrain is presented on a shared display, the terrain mode and terrain information should be easily distinguishable from weather and other features.

(14) For color displays, the selected colors should complement the discreet visual and aural alerts that are presented to the flightcrew. Accordingly, any colors that are used for the threat terrain display should match the colors used for the discreet visual alerts.

(15) If additional terrain views are provided, they must not present information that is inconsistent or incompatible with the features described above. Each view should be consistent with the other as far as color, scale, and textural information. When transitioning between views, the range scale should remain the same for each view. Each view will be carefully evaluated to ensure that it does not interfere with or reduce the effectiveness of the TAWS as a whole, and that it meets the other relevant portions of this

Advisory Circular. Since such displays may include functionality that goes beyond the scope of this AC, they also will be evaluated based on other relevant regulations, guidance material, or industry standards, as appropriate.

c. **Pop-Up Mode-Switching Functionality.**

(1) General Considerations. If implemented, an automatic pop-up feature should incorporate the following considerations in its design:

(a) The pop-up functionality should automatically display TAWS-related information when a TAWS caution alert occurs.

(b) The pop-up functionality should be implemented consistently for weather, Predictive Windshear System (PWS), and traffic alerts.

(c) The display system should be designed so that it is very evident that an automatic pop-up has occurred.

(d) The terrain display mode should be annunciated on the display. If this is not feasible then a mode annunciation light should be installed near the terrain display.

(e) Manually switching back to the original mode of operation should require minimal effort.

(f) Automatic switching back to the original mode of operation after the caution or warning ceases should not be allowed unless it is part of the aircraft design philosophy.

(2) Pop-Up Inhibit Feature. For dual displays, pop-up functionality can be inhibited if the terrain map is on at least one display when a terrain alert occurs. However, if the terrain map is not on a display when a terrain alert occurs, the terrain map, with the alerts, should be automatically displayed on both the left and right displays.

(3) Prioritizing Pop-Up Displays Between Systems. In installations where the TAWS and the Predictive Windshear System (PWS) share the same display, and automatic pop-up functionality is employed, the display priorities indicated in **Table 1**, below, are recommended:

TABLE 1.

Prioritization of Pop-Up Displays Where TAWS and Predictive Windshear System (PWS) Share the Same Display

Priority		Description
Highest	1	Terrain Awareness Warning
	2	Predictive Windshear Warning
	3	Terrain Awareness Caution
	4	Predictive Windshear Caution
	5	Standard Terrain Display
Lowest	6	Weather Radar

(4) If the system provides alerting for obstacle threats, the prioritization for warnings and cautions should be the same as those for terrain. The priorities are listed in the table above.

d. **Auto-Range Switching Mode**. An auto-ranging function during alerts is not required. However, if provided, an auto-ranging display should be designed so that it is very evident to the flightcrew that the range has been automatically selected. The range selected for auto-ranging should provide a usable depiction of the threat on the display. Switching back to a manually-selected range should require minimal effort.

14. ALERTS.

a. In addition to being complaint with the requirements of § 25.1322, the TAWS alerts should be clear, concise, and unambiguous.

b. The Human Factors Plan specified in the PSCP (see paragraph 8.f.) should be used to establish that the visual and aural alerts are consistent with the alerting philosophy of the airplane flight deck in which the TAWS equipment is installed. This is particularly important with retrofit installations, which may include the re-use of previously-installed alerting annunciations. The plan should consider that the visual alerts are:

- located in the pilots primary field of view, as defined by the human factors plan
- consistent with their associated voice, or aural call out
- consistent with the colors specified in § 25.1322, both in the discrete and textural display formats.

15. ALERT PRIORITIZATION.

a. Installations of TAWS on aircraft also equipped with a Reactive Windshear System (RWS), Predictive Windshear System (PWS), and Traffic Alert and Collision Avoidance System (TCAS) should include an alert prioritization scheme such that:

(1) Only one alert is given at any one time, and

(2) Alerts for situations requiring immediate action by the flightcrew have priority in situations where conditions for multiple alerts may occur.

> **NOTE**: In older aircraft, the system architecture may preclude the prioritization of alerts for multiple alerting systems. If such is the case, a prioritization scheme is not required. However, if simultaneous alerts can be given, then the aural words must be understandable and the associated visual alerts must not be confusing to the flightcrew.

b. Implementing this prioritization scheme within the TAWS equipment is acceptable. **Table 2**, below, displays an example of the recommended alert prioritization:

TABLE 2.
Recommended Alert Prioritization between the TAWS and Other Systems Installed

Priority		Description
Highest	1	Reactive Windshear Warning
Class A/B	2	Sink Rate Pull-Up Warning *(Excessive Rates of Descent)*
Class A	3	Terrain Closure Pull-Up Warning *(Excessive Closure Rates)*
Class A/B	4	Terrain Awareness Pull-Up Warning *(FLTA)*
	5	Predictive Windshear Warning
	6	Minimums *(Voice Callouts)*
Class A/B	7	Terrain Awareness Caution *(FLTA)*
Class A	8	Too Low Terrain *(Flight Into Terrain When Not in Landing Configuration)*
Class A/B	9	PDA *("Too Low Terrain")* Caution
Class A/B	10	Altitude Callouts *(Voice callouts)*
Class A	11	Too Low Gear *(Flight Into Terrain When Not in Landing Configuration)*
Class A	12	Too Low Flaps *(Flight Into Terrain When Not in Landing Configuration)*
Class A/B	13	Sink Rate *(Excessive Rates of Descent)*
Class A/B	14	Don't Sink *(Negative Climb Rate or Altitude Loss After Take-off)*
Class A	15	Glideslope *(Excessive Downward Deviation From an ILS Glideslope)*
	16	PWS Caution
	17	Approaching Minimums *(Voice Callouts)*
	18	Bank Angle *(Voice Callouts)*
	19	Reactive Windshear Caution
	20	TCAS RA *("Climb," "Descend," etc.)*
Lowest	21	TCAS TA *("Traffic, Traffic")*

16. SYSTEM INHIBIT.

a. A means for one of the flightcrew to inhibit the following TAWS functions must be provided:

- FLTA
- PDA

- Basic GPWS - Flight into terrain when not in the landing configuration
- Basic GPWS – Excessive downward deviation from the ILS glideslope

b. Care should be taken to ensure that instinctive, inadvertent, or habitual reflexive action by the flightcrew does not inhibit the these functions. (Provisions for a guarded switch could be a possible means of compliance.) Appropriate annunciation of the inhibited functions must be provided to the flightcrew. Flightcrew procedures for disabling various TAWS functions should be identified in the Airplane Flight Manual (AFM). For Class A equipment, inhibiting the FLTA and PDA functionality should not affect the Basic GPWS functions.

17. FLIGHT DATA RECORDER. For those applications that require crash-survivable flight data recording in accordance with the requirements of § 25.1459(e) (Flight recorders), a means should be provided to record the FLTA alerts in the same manner as is currently done for the Basic GPWS. (It is not necessary to distinguish between Basic GPWS and the new FLTA and PDA alerts.) A means also should be provided to record a FLTA and/or PDA-inhibit.

18. SYSTEMS EVALUATIONS WITH SIMULATORS. Simulators may be used as a tool to evaluate specific installations of TAWS. The level of simulation fidelity required will depend on the type of credit being sought. Some of the characteristics of a TAWS installation and flight deck integration that may be evaluated via simulation are:

- displays,
- alert prioritization,
- mode transitions,
- pop-up displays,
- auto-ranging,
- self test,
- operational workload issues,
- accessibility and usability of the TAWS controls,
- and systems failure modes.

19. GROUND TEST CONSIDERATIONS.

a. A ground test should be conducted for each TAWS installation. The level of testing required will be determined by the scope of the installation (First of a Model vs. Follow-on). Some items to consider for ground test should include:

- an acceptable location of TAWS controls, displays, and annunciators;

- exercise of self-test functions;
- evaluation of identified failure modes;
- evaluation of all discretes and TAWS interfaces;
- electro-magnetic interference (EMI)/electro-magnetic compatibility (EMC) testing; and
- electrical transient testing.

b. Considerations can also be made for evaluating display characteristics if it can be shown that all of the performance aspects of the display that are available during flight can be evaluated on the ground.

20. FLIGHT TEST CONSIDERATIONS.

a. The level of flight test required to validate a particular TAWS installation will be based on the type of airplane, airplane system architecture, and credit given for previously certified installations, simulation and ground testing. The actual requirement for a flight test needs to be evaluated for each installation. First time/model installations and new sensor inputs will require flight test. Follow on installations that introduce changes in flight deck configurations may require flight testing if they can not be evaluated as specified in paragraph 18. of this AC. The evaluation of new sensor models may require flight test, unless it can be shown through a sensitivity analysis that the new sensor's dynamic characteristics during flight are compatible with the current sensor parameters, and will not effect the performance of the TAWS.

The following examples are intended to assist in determining the flight test guidelines for some potential or likely TAWS configurations. **Table 3**, which follows, provides a summary of these examples.

(1) Example 1. This is the first time the vendor's equipment has been installed in any airplane for the purpose of receiving a first time TC/STC approval. If such is the case, then a complete and thorough Ground and Flight Test program should be conducted to verify the adequacy of the installation.

(2) Example 2. This involves a follow-on installation of a previously approved TAWS in which a required sensor input has not been previously approved for the specific vendor's equipment. For example, if the sensor that provides barometric altitude (or equivalent) to the TAWS equipment has not been previously approved, the flight test evaluation should focus on the TAWS functions affected by barometric altitude such as FLTA and PDA.

(3) Example 3. This involves a follow-on installation of a previously approved TAWS in which the Terrain Display has not been previously approved. In this case, the

focus of the flight test evaluation should be on display related issues and tests specified in paragraph 20.e. (Terrain Display Flight Test Considerations) of this AC.

(4) Example 4. This involves a follow-on installation of a previously approved TAWS in which the horizontal position source sensor input has not been previously approved for the specific vendor's equipment. In this case, the focus of the flight test evaluation should be on the adequacy of the horizontal position source and the display of the terrain as determined by that horizontal position source. In addition, since the navigation system provides track and ground speed information to TAWS, which affect the alerting logic, an FLTA functional flight test evaluation test is warranted. Some basic GPWS installations use the horizontal position information to desensitize some of the TSO C92c modes. Verification of the function and proper interface installation may require additional flight testing for the basic GPWS.

(5) Example 5. This involves a follow-on installation of a previously approved TAWS in which the radio altitude to the TAWS equipment has not been previously approved. In this case, the focus of the flight test evaluation should be on the TAWS functions affected by radio altitude such as one of the Basic GPWS modes or the PDA function. Only one test is required to assure that the radio altimeter input is properly installed to the TAWS. This example does not apply to Class B TAWS.

(6) Example 6. This involves an initial installation of a vendor's TAWS in an airplane that was previously approved with Basic GPWS equipment (per TSO- C-92c) from the same vendor, Same basic GPWS algorithms, and the same sensors that are used for the GPWS installation are used for the TAWS installation. If such is the case, then Basic GPWS testing is not required to be accomplished for the TAWS installation. However, there are exceptions; the following situation is an example:

> **Exception**: A basic GPWS has a TSO C92a that is installed in an aircraft. Subsequently, the TAWS (TSO C151a) is to be installed. The sensors used for the basic GPWS (TSO C92c) used for the TAWS are the same, except that some of the algorithms were changed and some features were added. Ultimately, an evaluation must be made to check the differences between the basic GPWS algorithms that were certified and the basic GPWS algorithms used for the TAWS to determine if any flight testing is necessary.

TABLE 3.

Flight Test Matrix

TAWS FUNCTIONS	*Example 1*	*Example 2*	*Example 3*	*Example 4*	*Example 5*	*Example 6*
FLTA	X	X	X	X		X
PDA	X	X			X or	X
Basic GPWS *	X				X	
Terrain Display	X		X	X		X
Horizontal Position Source	X			X		X

* *Class A equipment*

b. **FLTA Flight Test Considerations.**

(1) Flight testing to verify the proper operation of the FLTA function can be conducted in an area where the terrain or obstacle elevation for the test runs is known to be within approximately 300 feet.

(2) Test runs are recommended to be level flight at approximately 500 feet above the terrain/obstacle of interest. The test runs should verify that:

(a) all alerts (caution and warnings) are given at an appropriate point in the test run,

(b) all pop-up, auto-range, or other display features are working correctly, and

(c) the display depicts the terrain accurately.

NOTE: The terrain selected should be at least 15 NM from the nearest airport to conduct the test as described. If this is not practical, the fly-over altitude will have to be lowered to 300 feet or less above the terrain/obstacle in order to generate a TAWS alert.

c. **PDA Flight Test Considerations.**

(1) Flight testing to verify the proper operation of the PDA function can be conducted in any airport area within 10 NM of the nearest runway.

(2) The airplane should be configured for landing at approximately 1500 feet AGL along the final approach segment of the runway at approximately 10 NM from the runway.

(3) At the 10 NM point, a normal three degree flight path angle descent can be initiated and maintained until the PDA alert occurs.

> **NOTE**: The runway selected for this test should be relatively free from terrain/obstacles to preclude activation of the FLTA function. If not feasible, then increase the barometric altitude by 1 in. hg to allow radio altitude inputs to trigger a PDA alert. Approximately level terrain along the final approach segment will exercise the PDA function. This test may also exercise the 500 foot voice callout. The adequacy of the PDA aural alert should be verified during this test. This test also will verify the adequacy of the airport database, the navigation source input, and the barometric and/or radio altitude inputs to TAWS.

d. **Basic GPWS Flight Test Considerations.** Flight testing to verify the proper operation of Basic GPWS functions can be conducted in any area where the terrain elevation is known to the flightcrew. The following information is intended to provide guidance for conducting flight tests to exercise and verify the proper operation of each GPWS function. The need to conduct flight testing for follow-on TAWS installations will depend upon the nature of the new or modified sensors and their impact on that particular GPWS function.

(1) Excessive Rates of Descent. This test can be conducted at any location but descents toward near level terrain are recommended for best results and ease of correlation with DO-161 envelopes. For Class A equipment, exercising this test verifies the proper installation of barometric altitude (and the corresponding computation of barometric altitude rate) and radio altitude. For Class B equipment, exercising this test verifies the proper installation of barometric altitude, the height above terrain as determined from the GPS position and the corresponding terrain elevation from the terrain database. Only one test run is required to determine proper installation.

(2) Excessive Closure Rate to Terrain. This test must be conducted in an area of known rising terrain. It is recommended that one level test run at an altitude between 500-1000 feet above the terrain elevation be conducted. For Class A equipment only, this test will verify the proper installation of the radio altimeter.

(3) Negative Climb Rate or Altitude Loss after Takeoff. This test is conducted immediately after takeoff before climbing above 700 AGL or above runway elevation. For Class A equipment, exercising this test verifies the proper installation of barometric altitude, barometric altitude rate and radio altitude. For Class B equipment, exercising this test verifies the proper installation of barometric altitude and height above terrain as

determined from the GPS position and the corresponding terrain elevation from the terrain database.

(4) Flight into Terrain when Not in Landing Configuration. This test should be conducted while on a visual approach to a runway. For Class A equipment only, exercising this test verifies the proper installation of barometric altitude, barometric altitude rate and radio altitude as well as the gear and flap sensor inputs to TAWS.

(5) Excessive Downward Deviation from an ILS Glideslope. This test should be conducted during an ILS approach. For Class A equipment only, this test will verify the proper installation of the ILS Glideslope input to TAWS.

(6) Voice Callout "Five Hundred Feet." This test is conducted during an approach to a runway. For Class A and B equipment, this test will verify the proper installation of barometric altitude, radio altitude, and height above terrain as determined by either radio altitude or by access to the terrain database.

e. **Terrain Display Flight Test Considerations.**

(1) Flight testing to verify the proper operation of the Terrain Display should be conducted while verifying all the other required TAWS functions.

(2) Emphasis should be placed on verifying compliance with the provisions specified in paragraph 13.a. (Terrain Display) of this AC during normal airplane maneuvering during all phases of flight. Pop-up and auto-ranging features should be evaluated, if applicable.

(3) The FAA recommends that the applicant perform sustained turns to evaluate:

- symbol stability,
- flicker,
- jitter,
- display update rate,
- color cohesiveness,
- readability,
- the use of color to depict relative elevation data,
- caution and warning alert area depictions,
- map masking, and
- overall suitability of the display.

f. **Added Features Flight Test Considerations.** Flight testing may be required to verify the proper operation of added features such as:

- windshear detection,
- bank angle,
- altitude call outs "Approaching Minimums," or
- other features not required by TSO-C151a.

g. **Pressure Altitude Variations in Cold Weather.** The TAWS may be designed to account for the effects of cold weather on barometric altitude, while determining vertical position. Flight testing may be required, unless a suitable verification procedure can be conducted. This will depend on the design of the cold weather compensation.

21. AIRPLANE FLIGHT MANUAL (AFM)/AIRPLANE FLIGHT MANUAL SUPPLEMENT (AFMS). The applicant should make an evaluation to determine if there are any limitations of the system and, if so, how they will affect aircraft operations. Any limitations affecting operations must be included in the AFM/AFMS. As a minimum, the applicant should provide instructions in the Limitations Section of the AFM/AFMS that include the following:

a. **Limitations**. The following instructions should be included in the Limitations section of all AFM/AFMS:

(1) Navigation must not be predicated upon the use of the TAWS.

> **NOTE**: The Terrain Display is intended to serve as a situational awareness tool only. It may not provide the accuracy and/or fidelity on which to solely base decisions and plan maneuvers to avoid terrain or obstacles.

(2) To avoid giving unwanted alerts, the TAWS must be inhibited when landing at an airport that is not included in the airport database.

(3) The use of the terrain awareness warning and terrain display functions is prohibited during QFE (atmospheric pressure at airport elevation) operations.

> **NOTE**: This limitation may not apply to systems that use other sources of altitude measurement to determine the airplanes vertical position.

b. **Restricted Areas of Operation**.

(1) Areas of operation or other factors that adversely affect navigation performance to the extent that the TAWS will be potentially unreliable or misleading should be identified in the AFM/AFMS. Areas of operation where the terrain database resolution or accuracy leads to nuisance alerts also should be identified. This situation may occur if:

(a) the data are not properly analyzed;

(b) there are not enough data to map the terrain adequately;

(c) the resolution of the data is not adequate for the type of approved position source; or

(d) there are changes in the area (volcanoes, earthquakes, construction) that have not been noted.

(2) A route structural analysis (RSA) may be needed to identify those airports or runways that are susceptible to nuisance alerts. This analysis can be accomplished by computer simulation. Engine-out procedures also should be considered when developing the RSA.

c. **Operational Considerations for Normal/Abnormal Procedures**. In addition to the GPWS operational procedures, consider the following:

(1) Terrain Awareness Caution. When a terrain awareness CAUTION occurs, verify the airplane flight path and correct it, if required. If in doubt, perform a climb until the CAUTION alert ceases.

(2) Terrain Awareness Warning. If a terrain awareness WARNING occurs, immediately initiate and continue a climb that will provide maximum terrain clearance, or any similar approved vertical terrain escape maneuver, until all alerts cease. Only vertical maneuvers are recommended, unless operating in visual meteorological conditions (VMC), and/or the pilot determines, based on all available information, that turning in addition to the vertical escape maneuver is the safest course of action.

(3) Cold Weather. For operations in cold weather, either the system should be able to account for variations in cold weather at temperatures at or below 0° Celsius, or additional flightcrew procedures should be considered to address pressure altitude limits for vertical position determination. Limitations may be needed to address insufficient determination of the airplane's vertical position in cold weather temperatures.

(4) Mode 4. A procedure must be established for the operation of the inhibition of Mode 4 warnings based on flaps being in other than the landing configuration, as required by § 121.360.

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